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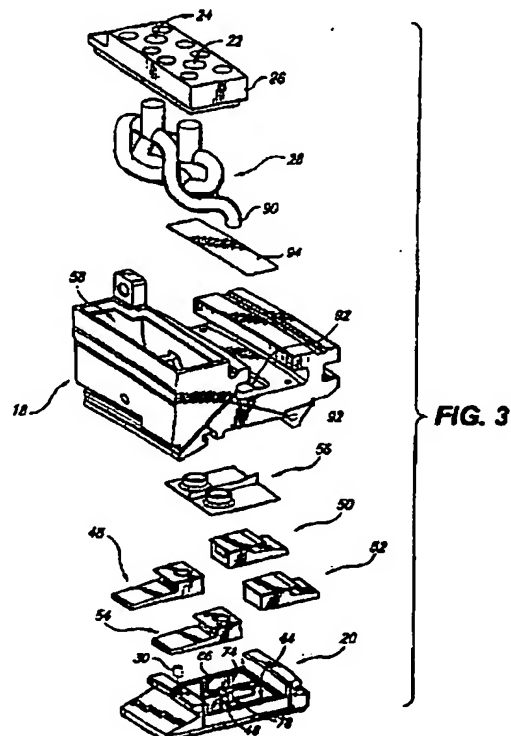
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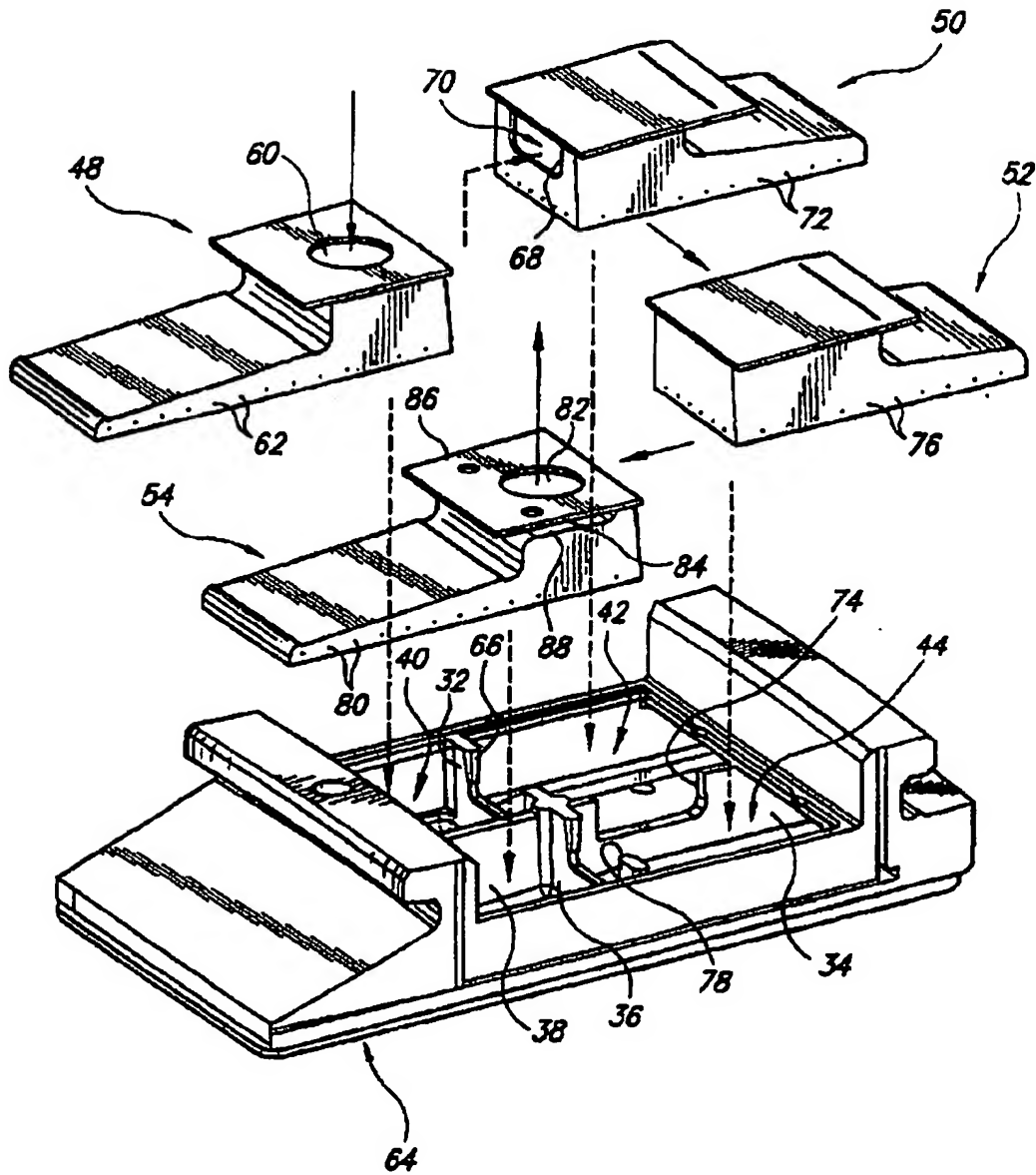
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(54) **Closed circuit steam cooled turbine shroud**

(57) A turbine shroud cooling cavity is partitioned to define a plurality of cooling chambers (40, 42, 44, 46) for sequentially receiving cooling steam and impingement cooling of the radially inner wall of the shroud (20). An impingement baffle (48, 50, 52, 54) is provided in each cooling chamber (40, 42, 44, 46) for receiving the cooling media from a cooling media inlet in the case of the first chamber or from the immediately upstream chamber in the case of the second through fourth chambers and includes a plurality of impingement holes for effecting the impingement cooling of the shroud inner wall.



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**FIG. 4**

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**Description**

[0001] The present invention relates to the cooling of turbine shrouds and, more particularly, to an apparatus for the impingement cooling of turbine shrouds as well as a system for flowing a cooling medium, in series, through several cooling cavities of a turbine shroud in a single, closed circuit.

[0002] Shrouds in an industrial gas turbine engine are located over the tips of the bucket. The shrouds assist in creating the annulus that contains the hot gas path air used by the buckets to produce rotational motion and, therefore, power. Thus, the shrouds are used to form the gas path of the turbine section of the engine. In advanced gas turbine designs, it has been recognized that the temperature of the hot gas flowing past the turbine components could be higher than the melting temperature of the metal. It is therefore necessary to establish a cooling scheme to protect the hot gas path components during operation.

[0003] Typical turbine shrouds are cooled by conduction, impingement cooling, film cooling or combinations of the above. More specifically, one method for cooling turbine shrouds employs an air impingement plate which has a multiplicity of holes for flowing air through the impingement plate at relatively high velocity due to a pressure difference across the plate. The high velocity air flow through the holes strikes and impinges on the component to be cooled. After striking and cooling the component, the post-impingement air finds its way to the lowest pressure sink.

[0004] Cooling air usage in a gas turbine is very costly for performance and emissions. However, as noted above, high technology engines produce high firing temperatures and the hot gas path components need to be actively cooled to be able to withstand the high gas path temperatures encountered under these circumstances.

[0005] Steam has been demonstrated to be a desired alternative cooling media for cooling gas turbine parts, particularly for combined-cycle plants. However, because steam has a higher heat capacity than the combustion gas, it is inefficient to allow coolant steam to mix with the hot gas stream. Consequently, it is desirable to maintain cooling steam inside the hot gas path components in a closed circuit. Using a closed circuit cooling system achieves the objectives of greater performance with less emissions.

[0006] U.S. Patent No. 5,391,052, the disclosure of which is incorporated herein by this reference, describes apparatuses and methods for impingement cooling of turbine components, particularly turbine shrouds using steam as a cooling medium. U.S. Patent No. 5,480,281, the disclosure of which is incorporated herein by this reference, provides an apparatus for impingement cooling turbine shrouds in a manner to reduce cross flow effects as well as a system for flowing a cooling medium, in series, through a pair of cooling cavities of the turbine shroud in a single flow circuit.

While the apparatuses and methods disclosed in these patents afford effective steam cooling of turbine shrouds, there remains a continuing need for improving turbine shroud cooling while minimizing the amount of cooling media required and reducing cross flow effects.

[0007] One embodiment of the present invention provides an improved closed cooling flow circuit for cooling turbine shrouds which provides for flowing a cool medium through a plurality of cooling chambers defined in the cooling cavity of the shroud so as to achieve a series of impingement cooling operations to maximize the cooling of the wall of the shroud exposed to the hot gas path and to minimize detrimental cross flow effects without reducing the area that is subject to impingement cooling.

[0008] The closed circuit cooling configuration described hereinbelow may be used with any cooling medium. However, in the presently preferred embodiment, the cooling medium is steam and thus steam will generally be referred to hereinbelow in a non-limiting manner as the cooling medium.

[0009] The invention is embodied, therefore, in an apparatus in which steam is brought on board into the outer shroud and split so as to be directed to the respective inner shrouds. Within each inner shroud, the steam or other cooling medium is impinged on the shroud inner surface opposite the hot gas path surface of the inner shroud. The post impingement steam flows into a second chamber of the inner shroud to again be impinged on the shroud inner surface for impingement cooling of that portion of the inner shroud. In the presently preferred, exemplary embodiment, the flow of post impingement steam and re-impingement of the inner shroud surface is then repeated through third and fourth chambers of the inner shroud. The spent steam is then returned to the system for being reused in the cycle. The system described hereinbelow is particularly adapted for a combined cycle system installation.

[0010] The present invention improves engine performance and reduces engine emissions while still maintaining the program requirements of part life and cost effectiveness.

[0011] The invention will now be described in greater detail, by way of example, with reference to the drawings, in which:-

FIGURE 1 is a schematic elevational view of a stage 1 shroud as disposed in a gas turbine;

FIGURE 2 is a perspective view of a steam cooled shroud assembly embodying the invention;

FIGURE 3 is an exploded perspective view of the assembly of FIGURE 2; and

FIGURE 4 is an exploded perspective view of the stage 1 inner shroud assembly.

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[0012] The shroud system which surrounds the buckets forming the gas path is composed of a number of outer shrouds which are the carriers of at least one inner shroud. In the illustrated example, one outer shroud and two inner shrouds make up one shroud assembly and forty-two (42) such shroud assemblies make up one shroud set. FIGURE 1 illustrates a shroud assembly 10 disposed radially outside the stage 1 buckets 12, only one of which is shown in FIGURE 1. Also shown in FIGURE 1 is the turbine shell interface 14, nozzle hook interface 16 and the inflow of cooling media shown by dash dot line S. As noted above, the closed circuit cooling configuration described hereinbelow may be used with any cooling medium. However, in the presently preferred embodiment the cooling medium is steam and thus steam will generally be referred to hereinbelow in a non-limiting manner as the cooling medium.

[0013] FIGURE 2 shows in greater detail the assembly of the outer shroud 18 and first and second inner shrouds 20 in this exemplary embodiment. The steam inlet port is shown at 22 whereas the outlet or exit port is designated 24. The inlet and exit ports are formed in the outer cover to the outer shroud 18.

[0014] FIGURE 3 shows this exemplary embodiment of the invention in greater detail. As noted above, the steam inlet port 22 and steam outlet port 24 are defined in outer cover 26. This particular system has steam tubes or piping 28 internal to the outer shroud that interfaces between the inlet and exit ports and the inner shroud interfaces for flowing the steam to respective inner shrouds, and returning spent cooling media, as described in greater detail below. This piping is enclosed in the outer shroud during shroud assembly.

[0015] Only one of the inner shrouds 20 is shown in FIGURE 3 although, as noted above, in this exemplary embodiment, two inner shrouds are associated with each outer shroud 18. The inner shroud is engaged with the outer shroud in a conventional manner and in this example an inner shroud anti rotation pin 30 extends therebetween. The inner shroud is partitioned by ribs or partition walls 32, 34, 36, 38 as shown in greater detail in FIGURE 4 to define four cooling chambers 40, 42, 44, 46. An impingement baffle inserts 48, 50, 52, 54 is disposed in each of these four chambers, as described in greater detail below, and an inner shroud cover plate 56 is provided to over lie the impingement baffles and to communicate with the respective cooling media tubes 28, 90 which extend through a compartment 58 therefor defined in the outer shroud 18. The cover plate 56 thus closes the chambers 40, 42, 44, 46 of the inner shroud 20 and controls/limits the cooling media inflow to and outflow from the inner shroud chambers.

[0016] Each impingement baffle divides its respective cooling chamber into a first, upstream compartment, and a second, downstream compartment. In the illustrated embodiment the impingement baffle insert defines an interior space that comprises the upstream chamber. Furthermore, in the illustrated embodiment,

the second, downstream compartment is the volume of the respective chamber that surrounds the impingement baffle insert, but is predominantly defined between the impingement baffle insert and the radially inner wall of the respective chamber. Each impingement baffle insert has a plurality of flow openings defined therethrough for communicating cooling medium from the first compartment through those openings into the second compartment for impingement cooling of radially inner wall of the chamber; which is also the radially inner wall of the shroud assembly 10.

[0017] Thus, as illustrated, steam is brought on board through an interface at the forward end of the outer shroud 18. The steam is then carried through the steam piping 28 and split between the two inner shrouds 20 associated with the respective outer shroud 18. In the inner shroud 20, the steam enters the first chamber 40 of the four illustrated chambers, more specifically a first, upstream compartment 60 thereof defined by the impingement baffle 48 received therewithin. The cooling steam is impinged through the impingement holes 62 on the bottom surface, and in this example also on the side wall, of the impingement baffle 48 and is impinged upon the inner surface of the inner shroud radially inner wall 64.

[0018] The post impingement steam then flows from the first chamber 40 to the second chamber 42. As shown, the impingement baffle 48 of the first chamber is spaced from the rearward wall 32 that separates the first and second chambers 40, 42 so as to allow post impingement cooling media to flow therebetween. One or more apertures, such as a cooling media aperture 66 is defined in wall 32 so as to allow the flow of that post impingement cooling media into the second chamber 42.

[0019] As shown in FIGURE 4, a cooling media inlet 68 is defined in the impingement baffle 50 of the second chamber 42 to receive the flow of cooling media from the first chamber 40 into the first, upstream compartment 70 of the second chamber that is defined there-within. The cooling media then flows through holes 72 to be again impinged onto the inner surface of the inner shroud radially inner wall 64.

[0020] The impingement baffle 50 of the second chamber 42 is spaced from the rib or wall 34 separating the second and third chambers 42, 44 so as to allow the post impingement cooling media to flow therebetween and then through the cutout or aperture(s) 74 defined in wall 34. An aperture (not shown) is defined in the impingement baffle 52 of the third chamber 44 so that the cooling media will flow into the upstream compartment of the third chamber, defined within the impingement baffle 52. The cooling media flows through holes 76 to again impinge on the inner shroud inner surface for further cooling thereof.

[0021] The flow of the cooling media through the inner shroud continues as the cooling steam flows through an aperture or cutout 78 in the wall 36 disposed between

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the third and fourth chambers 44, 46 into the impingement baffle 54 of the fourth, and in this embodiment final, cooling chamber 46. The cooling media is once again impinged by flowing through holes 80, to impinge against the inner surface of the inner shroud radially inner wall. The spent cooling steam thereafter flows to the steam exit 82 through a gap 84 defined between the exit plate 86 and the upper wall 88 of the impingement baffle 54, as shown. The steam flows through the exhaust passage defined by exit tube 90 to be combined with the spent cooling media from the second inner shroud (not shown in FIGURE 4) and exits through the steam piping 28 to an interface at the forward end of the outer shroud where it is returned to the combined cycle system.

[0022] As mentioned above, the illustrated system has piping 28 internal to the outer shroud 18 that interfaces between the inlet and exit ports 22, 24 and the inner shroud cover plate 56. This piping is enclosed in the outer shroud during the assembly of the shroud fabrication. An access hole 92 is provided in the outer shroud to access the piping connection to the inner shroud to inspect the connection to ensure that the connection is satisfactory. This access has been covered by a plate 94, as shown in FIGURE 3, to complete the shroud cooling system.

[0023] For the sake of good order, various aspects of the invention are set out in the following clauses:-

1. Impingement cooling apparatus for a turbine shroud assembly having inner and outer walls spaced from one another to define a cooling cavity therebetween, comprising:

partition walls provided in said cavity to define at least four cooling chambers within said cavity, each said cooling chamber having a cooling medium inlet and a cooling medium outlet and defining a cooling medium flow path there-through; an impingement baffle being disposed in each said chamber to define upstream and downstream compartments therewithin, each said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium between said compartments through said openings; each said upstream compartment being in flow communication with the respective cooling medium inlet and each said downstream compartment being in flow communication with the respective cooling medium outlet;

a supply passage in communication with a first of said cooling chambers for supplying cooling medium to said upstream compartment of said first chamber for flow through the openings of the impingement baffle thereof into said downstream compartment of said first chamber for impingement cooling of said inner wall; an exhaust passage in communication with a

fourth of said cooling chambers for exhausting post-impingement cooling medium from said downstream compartment of said fourth chamber.

2. An impingement cooling apparatus as in clause 1, wherein said turbine shroud assembly comprises an outer shroud and at least one inner shroud, a said cooling cavity being defined in each said inner shroud, said supply passage being defined through said outer shroud for conducting cooling medium to a cooling medium inlet of said at least one inner shroud and wherein said exhaust passage extends through said outer shroud.

3. An impingement cooling apparatus as in clause 1, wherein at least one of said impingement baffles comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said upstream compartment of said respective chamber.

4. An impingement cooling apparatus as in clause 1, wherein each said impingement baffle comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said upstream compartment of said respective chamber.

5. An impingement cooling apparatus as in clause 1, wherein a first said partition wall is disposed between said first cooling chamber and a second said cooling chamber, a cooling media aperture being defined in said first partition wall for flowing cooling medium from said first chamber to said second chamber, said impingement baffle disposed in said first chamber being spaced from said first partition wall so that post impingement cooling media flows between said impingement baffle and said first partition wall and through said cooling media aperture to said second chamber.

6. An impingement cooling apparatus as in clause 5, wherein said impingement baffle disposed in said second chamber comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said upstream compartment of said second chamber, said cooling media inlet of said impingement baffle of said second chamber being disposed in flow communication with said cooling media aperture in said first partition wall, whereby said post impingement cooling media flowing through said cooling media aperture in said first partition wall flows substantially solely into said interior space of said impingement baffle

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Insert of said second chamber.

7. A system for cooling a turbine shroud comprising:

a shroud housing defining a plurality of chambers; 5  
 a first chamber of said plurality of chambers having an inlet for receiving cooling medium and a cooling medium outlet, said first chamber having an impingement baffle disposed therein 10  
 to define first and second compartments there-within, said first compartment of said first chamber being in flow communication with said inlet thereof and said second compartment of said first chamber being in flow communication with 15  
 said outlet thereof; said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium from said first compartment through said openings into 20  
 said second compartment for impingement cooling of a wall of said first chamber; a second chamber of said plurality of chambers having an impingement baffle disposed therein 25  
 to define first and second compartments there-within, said first compartment of said second chamber being in flow communication with said outlet of said first chamber for receiving cooling medium from said first chamber, said impinge- 30  
 ment baffle having a plurality of flow openings therethrough for communicating cooling medium from said first compartment through said openings into said second compartment for im- 35  
 pingement cooling of a wall of said second chamber, said second chamber having an outlet for post-impingement cooling medium to exit said second compartment thereof; a third chamber of said plurality of chambers 40  
 having an impingement baffle disposed therein to define first and second compartments, said first compartment of said third chamber being in flow communication with said outlet of said second chamber for receiving cooling medium from said second chamber, said impingement 45  
 baffle having a plurality of flow openings there-through for communicating cooling medium from said first compartment through said open- 50  
 ings into said second compartment for impingement cooling of a wall of said third chamber, said third chamber having an outlet for post-impingement cooling medium to exit said second compartment thereof; 55  
 a fourth chamber of said plurality of chambers having an impingement baffle disposed therein to define first and second compartments, said first compartment of said fourth chamber being in flow communication with said outlet of said third chamber for receiving cooling medium from said third chamber, said impingement baf-

file having a plurality of flow openings there-through for communicating cooling medium from said first compartment through said open-ings into said second compartment for impinge-ment cooling of a wall of said fourth chamber, said fourth chamber having an outlet for post-impingement cooling medium to exit said sec-ond compartment thereof; an inlet port in communication with said inlet of said first chamber for flowing cooling medium thereto; and an exit port in communication with said outlet of said fourth chamber for exhausting post-im-pingement cooling medium therefrom.

8. A system as in clause 7, wherein said turbine shroud comprises an outer shroud and at least one inner shroud, each said inner shroud defining a said shroud housing, a supply passage being defined through said outer shroud for conducting cooling medium to said inlet of said first chamber and wherein an exhaust passage extends through said outer shroud for exhausting post-impingement flow from said outlet of said fourth chamber.

9. A system as in clause 7, wherein at least one of said impingement baffles comprises an impinge-ment baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said respective chamber.

10. A system as in clause 7, wherein each said im-pingement baffle comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said respective chamber.

11. A system as in clause 7, wherein a first partition wall is disposed between said first chamber and said second chamber, a cooling media aperture be-ing defined in said first partition wall for flowing cool-ing medium from said first chamber to said second chamber, said impingement baffle disposed in said first chamber being spaced from said first partition wall so that post impingement cooling media flows between said impingement baffle and said first par-tition wall and through said cooling media aperture to said second chamber.

12. A system as in clause 11, wherein said impinge-ment baffle disposed in said second chamber com-prises an impingement baffle insert defining an in-terior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said second chamber, said cooling media inlet of said impinge-

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ment baffle of said second chamber being disposed in flow communication with said second compartment of said first chamber, whereby said post impingement cooling media flows substantially solely from said second compartment of said first chamber into said interior space of said impingement baffle insert of said second chamber.

13. A system as in clause 7, wherein a first partition wall is disposed between said first chamber and said second chamber, a cooling media aperture being defined in said first partition wall for flowing cooling medium from said first chamber to said second chamber, and wherein said impingement baffle disposed in said second chamber comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said second chamber, said cooling media inlet of said impingement baffle of said second chamber being disposed in flow communication with said cooling media aperture in said first partition wall, whereby said post impingement cooling media flowing through said cooling media aperture in said first partition wall flows substantially solely into said interior space of said impingement baffle of second chamber.

14. A method of cooling a turbine shroud by cooling medium impingement comprising the steps of:

providing a turbine shroud having at least four cooling chambers defined therein, an inlet port for flowing cooling medium thereto, and an exit port for exhausting spent cooling medium therefrom;

flowing cooling medium through said inlet port and into a first chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the first chamber into a first compartment and a second compartment;

directing the cooling medium flowing through said openings across said second compartment of said first chamber for impingement against a radially inner wall of the shroud to cool said wall;

flowing post-impingement cooling medium from said first chamber through an aperture defined in a wall thereof and into a second chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the second chamber into a first compartment and a second compartment;

directing the cooling medium flowing through

said openings across said second compartment of said second chamber for impingement against said radially inner wall of the shroud to cool said wall;

flowing post-impingement cooling medium from said second chamber through an aperture defined in a wall thereof and into a third chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the third chamber into a first compartment and a second compartment;

directing the cooling medium flowing through said openings across said second compartment of said third chamber for impingement against said radially inner wall of the shroud to cool said wall;

flowing post-impingement cooling medium from said third chamber through an aperture defined in a wall thereof and into a fourth chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the fourth chamber into a first compartment and a second compartment;

directing the cooling medium flowing through said openings across said second compartment of said fourth chamber for impingement against said radially inner wall of the shroud to cool said wall;

flowing post-impingement cooling medium from said fourth chamber through an exit defined in a wall thereof; and exhausting spent cooling medium through said exit port.

15. A method as in clause 14, wherein said step of providing a turbine shroud comprises providing an assembly including an outer shroud and at least one inner shroud, each said inner shroud having a said plurality of cooling chambers defined therewithin, a supply passage being defined through said outer shroud for conducting cooling medium to from said inlet port to said inner shroud, and an exhaust passage being defined through said outer shroud for exhausting post-impingement flow from said exit of said fourth chamber.

16. A method as in clause 14, wherein at least one of said impingement baffles comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said respective chamber.

17. A method as in clause 14, wherein each said

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impingement baffle comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said respective chamber.

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18. A method as in clause 14, wherein a first partition wall is disposed between said first chamber and said second chamber, said aperture of said first chamber being defined in said first partition wall for flowing cooling medium from said first chamber to said second chamber, said impingement baffle disposed in said first chamber being spaced from said first partition wall so that post impingement cooling media flows between said impingement baffle and said first partition wall and through said aperture to said second chamber.

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19. A method as in clause 14, wherein said impingement baffle disposed in said second chamber comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said second chamber, said cooling media inlet of said impingement baffle of said second chamber being disposed in flow communication with said second compartment of said first chamber, whereby said post impingement cooling media flows substantially solely from said second compartment of said first chamber into said interior space of said impingement baffle insert of second chamber.

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20. A method as in clause 14, wherein a first partition wall is disposed between said first chamber and said second chamber, wherein said aperture of said first chamber is defined in said first partition wall for flowing cooling medium from said first chamber to said second chamber, and wherein said impingement baffle disposed in said second chamber comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said second chamber, said cooling media inlet of said impingement baffle of said second chamber being disposed in flow communication with said aperture in said first partition wall, whereby said post impingement cooling media flowing through said aperture in said first partition wall flows substantially solely into said interior space of said impingement baffle of second chamber.

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#### Claims

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1. Impingement cooling apparatus for a turbine shroud assembly having inner and outer walls spaced from

one another to define a cooling cavity therebetween, comprising:

partition walls provided in said cavity to define at least four cooling chambers within said cavity, each said cooling chamber having a cooling medium inlet and a cooling medium outlet and defining a cooling medium flow path there-through; an impingement baffle being disposed in each said chamber to define upstream and downstream compartments therewithin, each said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium between said compartments through said openings; each said upstream compartment being in flow communication with the respective cooling medium inlet and each said downstream compartment being in flow communication with the respective cooling medium outlet;

a supply passage in communication with a first of said cooling chambers for supplying cooling medium to said upstream compartment of said first chamber for flow through the openings of the impingement baffle thereof into said downstream compartment of said first chamber for impingement cooling of said inner wall; an exhaust passage in communication with a fourth of said cooling chambers for exhausting post-impingement cooling medium from said downstream compartment of said fourth chamber.

2. An impingement cooling apparatus as in claim 1, wherein said turbine shroud assembly comprises an outer shroud and at least one inner shroud, a said cooling cavity being defined in each said inner shroud, said supply passage being defined through said outer shroud for conducting cooling medium to a cooling medium inlet of said at least one inner shroud and wherein said exhaust passage extends through said outer shroud.
3. An impingement cooling apparatus as in claim 1 or 2, wherein at least one of said impingement baffles comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said upstream compartment of said respective chamber.
4. An impingement cooling apparatus as in claim 1, 2 or 3, wherein each said impingement baffle comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said upstream compartment of said respective chamber.

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## 5. A system for cooling a turbine shroud comprising:

a shroud housing defining a plurality of chambers;

a first chamber of said plurality of chambers having an inlet for receiving cooling medium and a cooling medium outlet, said first chamber having an impingement baffle disposed therein to define first and second compartments there-within, said first compartment of said first chamber being in flow communication with said inlet thereof and said second compartment of said first chamber being in flow communication with said outlet thereof; said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium from said first compartment through said openings into said second compartment for impingement cooling of a wall of said first chamber;

a second chamber of said plurality of chambers having an impingement baffle disposed therein to define first and second compartments there-within, said first compartment of said second chamber being in flow communication with said outlet of said first chamber for receiving cooling medium from said first chamber, said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium from said first compartment through said openings into said second compartment for impingement cooling of a wall of said second chamber, said second chamber having an outlet for post-impingement cooling medium to exit said second compartment thereof;

a third chamber of said plurality of chambers having an impingement baffle disposed therein to define first and second compartments, said first compartment of said third chamber being in flow communication with said outlet of said second chamber for receiving cooling medium from said second chamber, said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium from said first compartment through said openings into said second compartment for impingement cooling of a wall of said third chamber, said third chamber having an outlet for post-impingement cooling medium to exit said second compartment thereof;

a fourth chamber of said plurality of chambers having an impingement baffle disposed therein to define first and second compartments, said first compartment of said fourth chamber being in flow communication with said outlet of said third chamber for receiving cooling medium from said third chamber, said impingement baffle having a plurality of flow openings therethrough for communicating cooling medium

from said first compartment through said openings into said second compartment for impingement cooling of a wall of said fourth chamber, said fourth chamber having an outlet for post-impingement cooling medium to exit said second compartment thereof;

an inlet port in communication with said inlet of said first chamber for flowing cooling medium thereto; and

an exit port in communication with said outlet of said fourth chamber for exhausting post-impingement cooling medium therefrom.

6. A system as in claim 5, wherein said turbine shroud comprises an outer shroud and at least one inner shroud, each said inner shroud defining a said shroud housing, a supply passage being defined through said outer shroud for conducting cooling medium to said inlet of said first chamber and wherein an exhaust passage extends through said outer shroud for exhausting post-impingement flow from said outlet of said fourth chamber.

7. A system as in claim 5 or 6, wherein at least one of said impingement baffles comprises an impingement baffle insert defining an interior space and having an inlet for flowing cooling media into said interior space, said interior space defining said first compartment of said respective chamber.

8. A method of cooling a turbine shroud by cooling medium impingement comprising the steps of:

providing a turbine shroud having at least four cooling chambers defined therein, an inlet port for flowing cooling medium thereto, and an exit port for exhausting spent cooling medium therefrom;

flowing cooling medium through said inlet port and into a first chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the first chamber into a first compartment and a second compartment;

directing the cooling medium flowing through said openings across said second compartment of said first chamber for impingement against a radially inner wall of the shroud to cool said wall;

flowing post-impingement cooling medium from said first chamber through an aperture defined in a wall thereof and into a second chamber of said plurality of chambers within the shroud;

flowing cooling medium through a plurality of openings defined in an impingement baffle dividing the second chamber into a first compart-

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ment and a second compartment;  
directing the cooling medium flowing through  
said openings across said second compart-  
ment of said second chamber for impingement  
against said radially inner wall of the shroud to  
cool said wall; 5  
flowing post-impingement cooling medium  
from said second chamber through an aperture  
defined in a wall thereof and into a third cham-  
ber of said plurality of chambers within the 10  
shroud;  
flowing cooling medium through a plurality of  
openings defined in an impingement baffle di-  
viding the third chamber into a first compart-  
ment and a second compartment; 15  
directing the cooling medium flowing through  
said openings across said second compart-  
ment of said third chamber for impingement  
against said radially inner wall of the shroud to  
cool said wall; 20  
flowing post-impingement cooling medium  
from said third chamber through an aperture  
defined in a wall thereof and into a fourth cham-  
ber of said plurality of chambers within the  
shroud; 25  
flowing cooling medium through a plurality of  
openings defined in an impingement baffle di-  
viding the fourth chamber into a first compart-  
ment and a second compartment;  
directing the cooling medium flowing through 30  
said openings across said second compart-  
ment of said fourth chamber for impingement  
against said radially inner wall of the shroud to  
cool said wall;  
flowing post-impingement cooling medium 35  
from said fourth chamber through an exit de-  
fined in a wall thereof; and  
exhausting spent cooling medium through said  
exit port. 40

9. A method as in claim 8, wherein said step of provid-  
ing a turbine shroud comprises providing an assem-  
bly including an outer shroud and at least one inner  
shroud, each said inner shroud having a said plu-  
rality of cooling chambers defined therewithin, a 45  
supply passage being defined through said outer  
shroud for conducting cooling medium to from said  
inlet port to said inner shroud, and an exhaust pas-  
sage being defined through said outer shroud for  
exhausting post-impingement flow from said exit of 50  
said fourth chamber.
10. A method as in claim 8 or 9, wherein at least one of  
said impingement baffles comprises an impinge-  
ment baffle insert defining an interior space and 55  
having an inlet for flowing cooling media into said  
interior space, said interior space defining said first  
compartment of said respective chamber.

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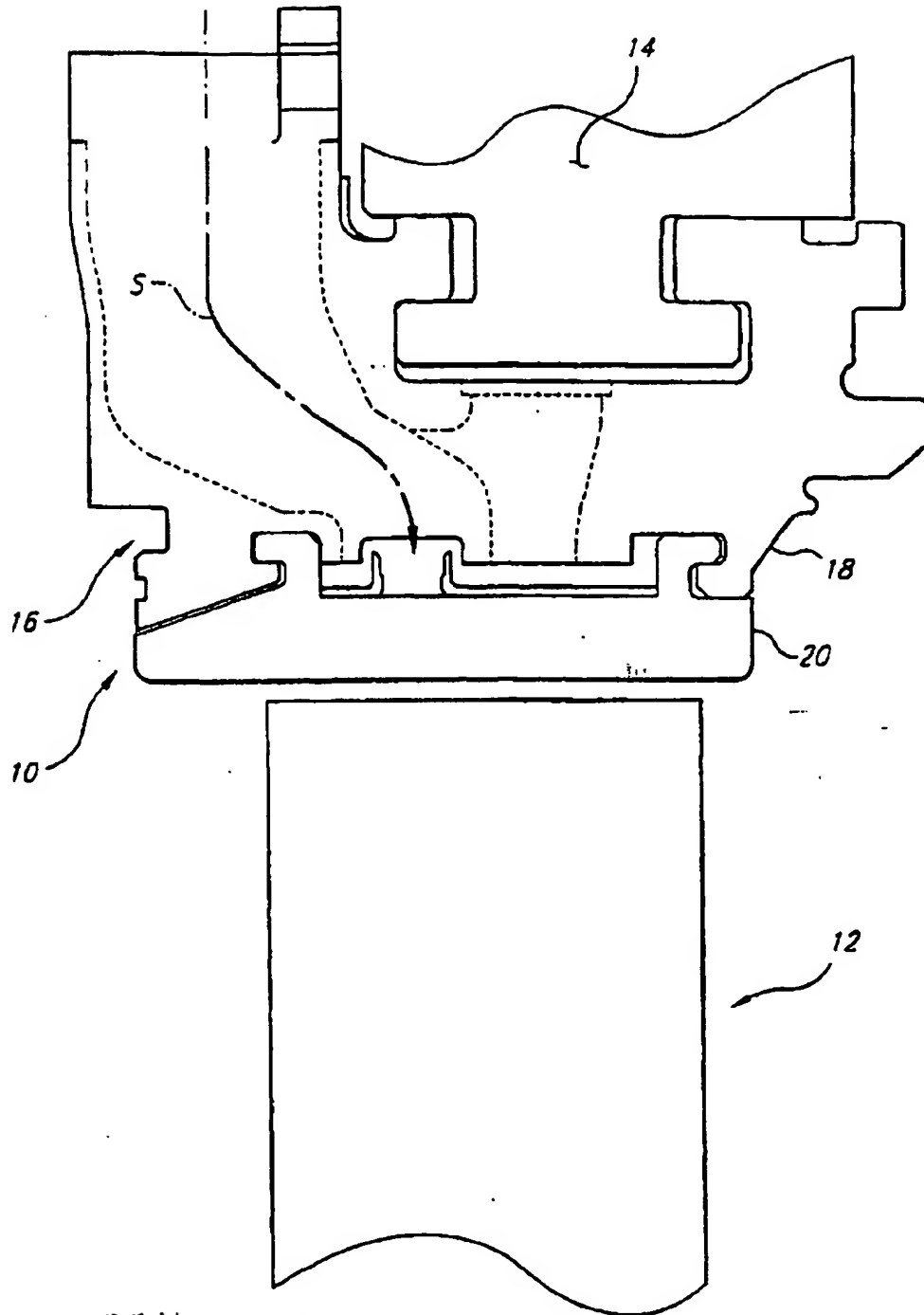
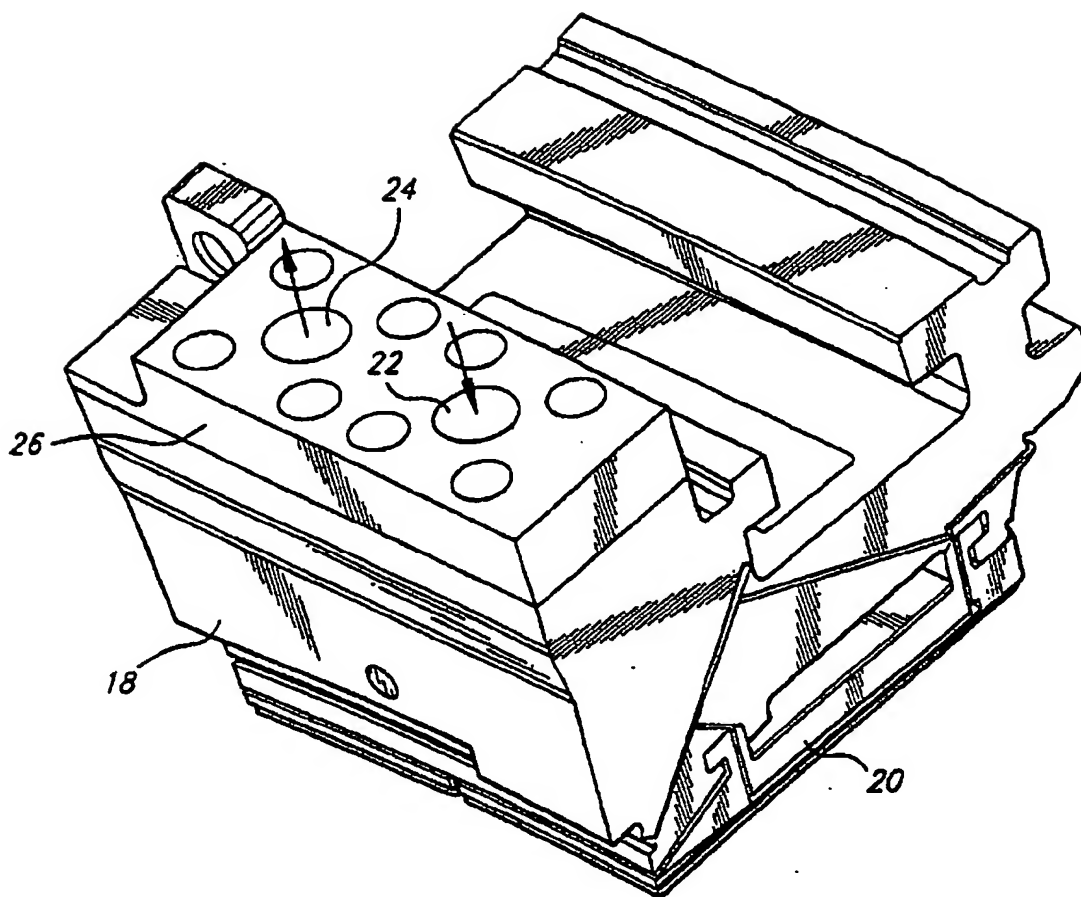


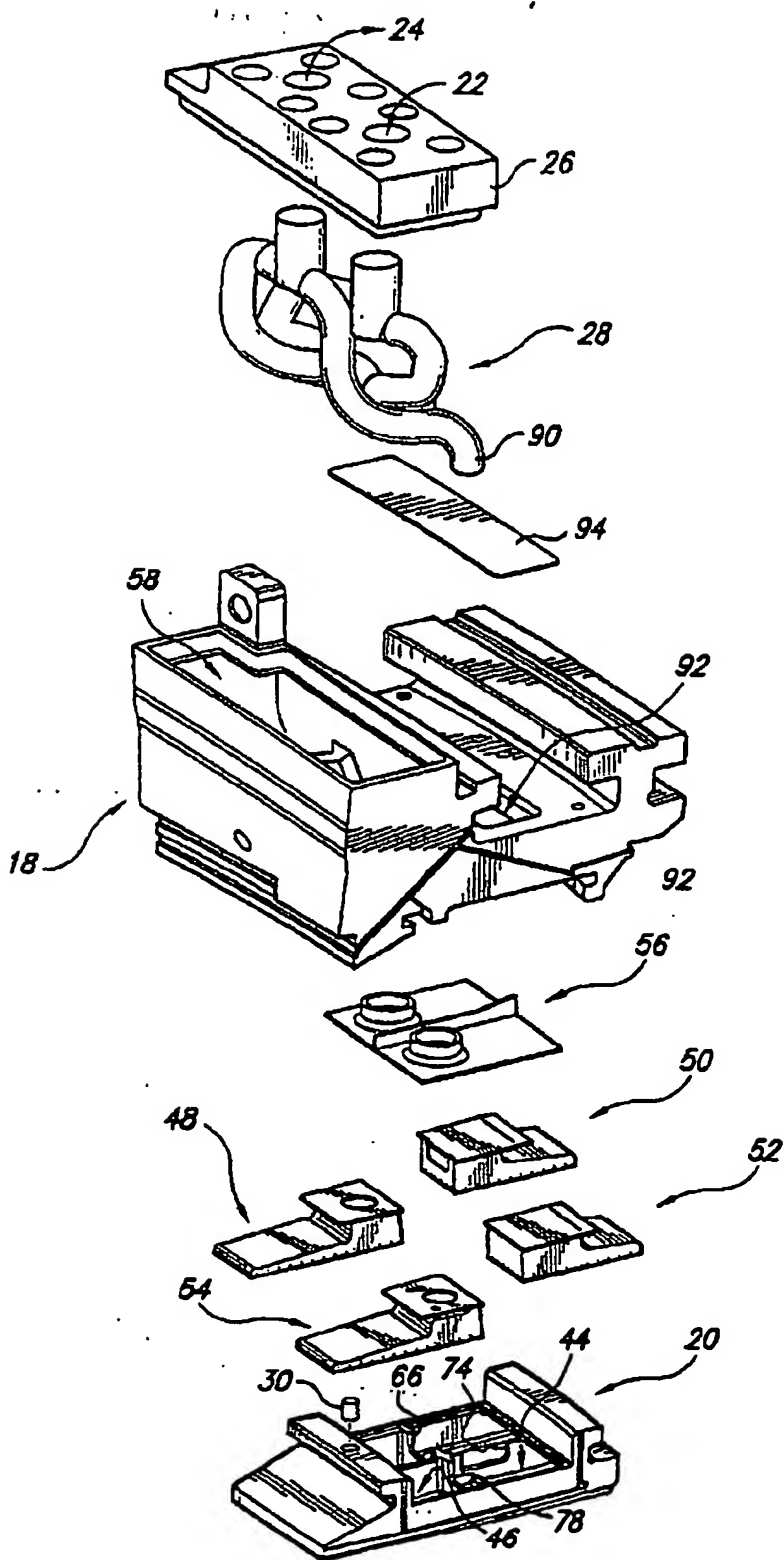
FIG. 1

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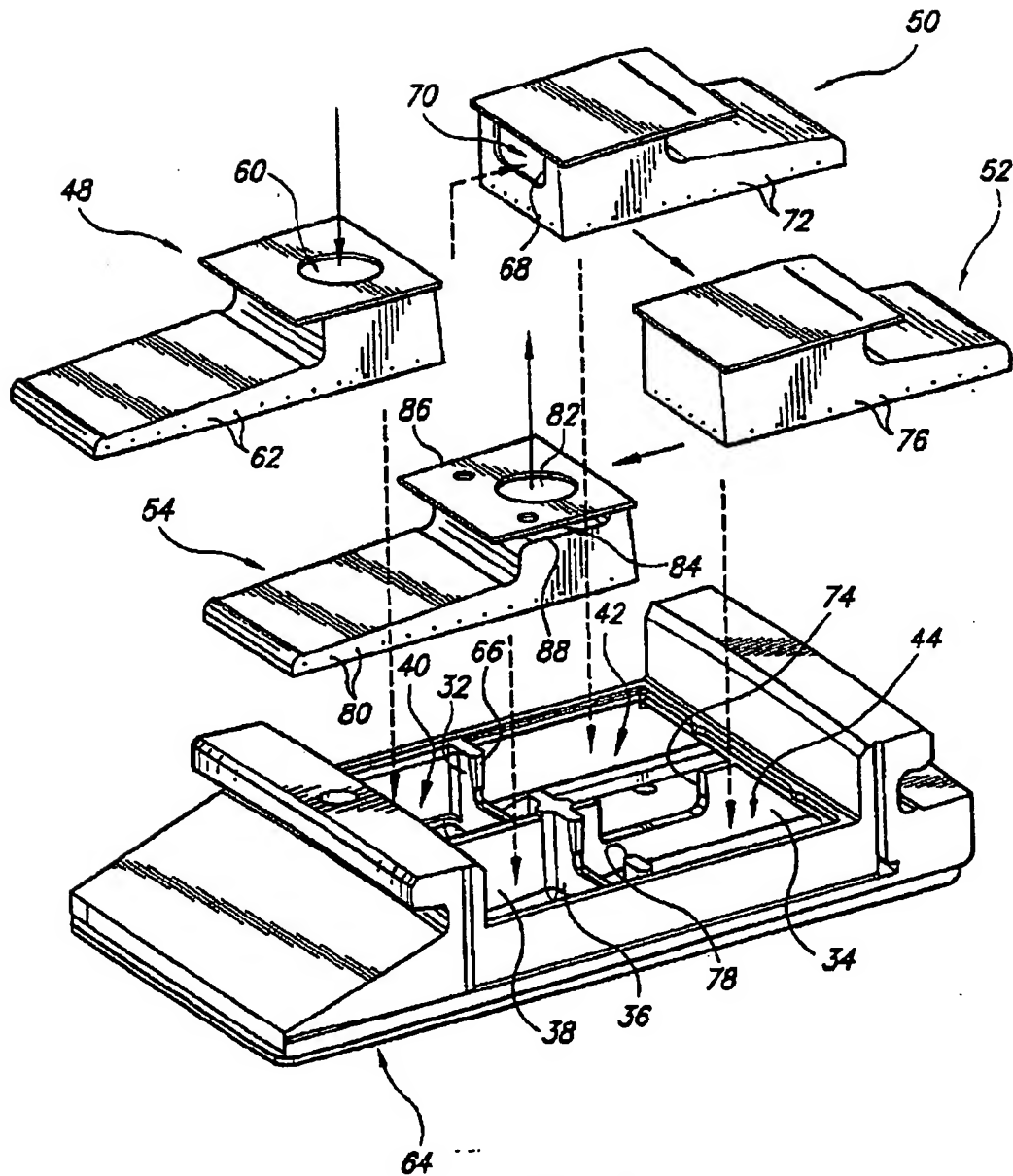


**FIG. 2**

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**FIG. 3**

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**FIG. 4**